REON

SACRAMENTO PLANT

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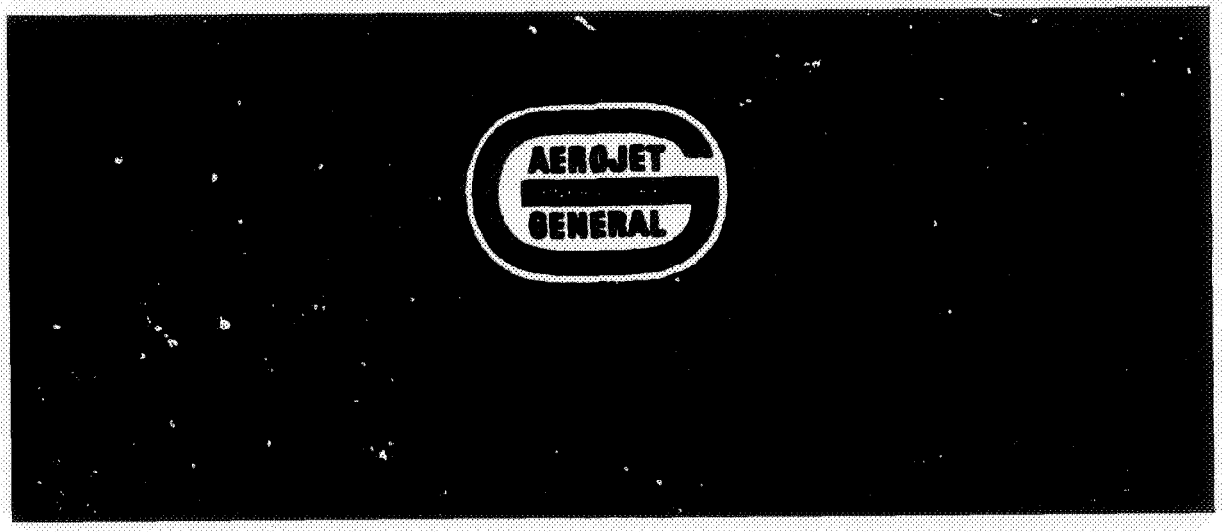
TO
AEC - NASA SPACE NUCLEAR PROPULSION OFFICE

FINAL TEST SPECIFICATIONS FOR PHASE I-A OF THE COUNTERMEASURES RADIATION EFFECTS PROGRAM (U) VOL. I - TEXT AND UNCLASSIFIED APPENDIXES

NERVA PROGRAM

CONTRACT SNP-1



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AEROJET GENERAL TIRE GENERAL

REPORT NO. RN-S-0324

FINAL TEST SPECIFICATIONS FOR PHASE I-A OF THE COUNTERMEASURES RADIATION EFFECTS PROGRAM (U)

SEPTEMBER 1966

ROCKET ENGINE OPERATIONS - NUCLEAR

NERVA PROGRAM CONTRACT SNP-1

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AEROJET-GENERAL CORPORATION
A SUBSIDIARY OF THE GENERAL TIRE & RUBBER COMPANY

FOREWORD

This report is issued in two volumes. Volume I, containing the text and Appendixes A and B, is unclassified. Volume II, containing Appendix C, is classified "Confidential-Restricted Data."

ABSTRACT

The test specification presented herein describes in detail the irradiation tests to be performed at the General Electric Company Vallecitos Atomic Laboratory in fulfillment of Phase I-A of the Countermeasures Radiation Effects Program, REON Sub-Subtask 1.9.1.

The experiments described in this document are the result of combined efforts of Aerojet-General REON, Sacramento, California, Aerojet-General Research and Engineering Division, Downey, California, General Electric Company Vallecitos Atomic Laboratory, Pleasanton, California, and the United States Army Picatinny Arsenal, Dover, N.J. This document is submitted in partial fulfillment of Contract SNP-1.

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INTRODUCTION

Aerojet-General Corporation's REON Division has initiated a program to investigate radiation effects on high explosives and propellants as they pertain to the NERVA Countermeasures Systems. This program has been designated the Countermeasures Radiation Effects Program, Su-Subtask 1.9.1.

This document is provided in two volumes to facilitate handling of the unclassified and classified portions. The unclassified volume will be used primarily by General Electric personnel to define operational procedures; the classified volume, containing properties of the materials to be tested, will be used primarily by the reactor safeguards personnel.

The specifications presented within this document are for the fifth portion of the Countermeasures Radiation Effects Program, Phase I-A. Included are descriptions of the experimental procedures to be used in Phase I-A to determine the effects of radiation on detonator performance. Test procedures for explosive samples will involve gathering data on weight loss, gas release (continuous and point measurement), thermogravimetric analysis, explosion temperature, differential thermal analysis, and vacuum stability - all as a function of integrated radiation energy deposition. To evaluate possible changes due to radiation, firing data will be obtained on detonators containing booster-type explosives.

The post-irradiation tests to be conducted on new explosive materials will be identical to those conducted on similar materials during Phase I-C. One instrumented capsule will be irradiated for each of three new explosives to determine the threshold exposure producing approximately 5% weight loss. A second capsule (non-instrumented) will then be exposed to a lower dosage to provide data on the rate of decomposition for each material.

Post-irradiation tests will also include evaluation of the effects of radiation on detonator assemblies. A prototype body has been designed which will allow four units to be loaded into the central hole of the standard non-instrumented Phase I capsule. Two capsules will be irradiation for each of three detonator designs. The first will be irradiated to a dose expected to produce approximately 5% weight loss as determined by data obtained during earlier phases of this program. After these units are performance-tested, the second capsule will be irradiated to a higher or lower dosage in an attempt to bracket the threshold for significant changes in performance. All post-irradiation tests on detonators will be made in the Radiological Materials Laboratory (RML) hot cell to minimize personnel radiation exposure. The tests will include weight loss, bridgewire resistance, current and voltage during firing, firing time, and plate dent. The same control panel and firing system used for pre-irradiation testing at Aerojet-Downey will be sent to the RML for conducting tests there.

This program is being performed under the joint direction of Aerojet-General Corporation (REON, and Downey Ordnance Research Division), U.S. Army (Picatinny Arsenal), and General Electric Company (Irradiation Processing Operations). Samples will be irradiated in the General Electric Test Reactor (GETR), Vallecitos Atomic Laboratory, Pleasanton, California. Post-irradiation tests will be performed jointly by Aerojet-General, General Electric, and Picatinny Arsenal personnel in the Radiological Materials Laboratory; General Electric personnel will be primarily responsible for hot-cell operations, radiological safety, and monitoring.

Upon the completion of Phase I-A, a technical review of the data produced, will be held at the General Electric Test Reactor. Each of the participating organizations will have representatives present at that review. Copies of the conclusions reached by the review group, together with the raw test data, will be forwarded to each organization for additional review, and for use in preparation of the Aerojet Final Test Report.

A list of the responsible personnel of each participating organization is given on the following page. The listing is presented in the order that these individuals should be contacted in case of emergency.

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II. DESCRIPTION OF IRRADIATION CAPSULES

Two types of irradiation capsules will be used in Phase I-A. These will be of the same design as the instrumented and non-instrumented capsules used in Phase I-C during irradiation in the GETR Z-trail cable facility. Up to 1.2 g of pyrotechnic material will be irradiated in each capsule.

The basic non-instrumented capsule was also used in all prior Phase I irradiation tests. An exploded view of this capsule is shown in Figure 1. The explosive samples will be loaded into a quartz vial in the central hole as during previous phases. The detonator assemblies have been designed so that four each will fit in the center hole along with the nickel and cobalt/aluminum flux wires and the temperature monitors (see Figure 2). The detonator bodies, end covers, and bridge wire are all of aluminum construction to minimize heating and neutron activation. The glass seal has a Kovar seal ring and a Kovar pin (the pin having a copper core). Kovar contains 54% iron, 29% nickel, and 18% cobalt. For purposes of activation analysis, the ring weighs 0.737 g, and the pin weighs 0.153 g (0.121 g of which is Kovar). Total Kovar per irradiation capsule is (0.737 + 0.121) (4) = 3.432 g.

Instrumented capsules will be used for three explosive samples. These capsules are of the type used in Phase I-C (Figure 3). They will be connected to a pressure measurement panel (Figure 4), with pressure and temperature continuously recorded on an L & N recorder mounted in a separate rack. This instrumentation is the same as used in Phase I-C.

The instrumented capsule (Figure 3) exhibits the same basic features as the non-instrumented capsule except that the cap is modified to accommodate the attachment of a 1/8-in.-dia aluminum tube. Housed within the aluminum tube are two fibrous-glass-insulated 28-gage copper-constantan thermocouple wires. These wires are continuous from the capsule's interior to the third floor of the GETR where measurements of temperature and pressure will be recorded throughout the irradiation period.

A complete summation of design data and analytical calculations regarding the irradiation capsules has previously been reported in Reference 1 (pages 11 through 44 and Appendixes A through E), Reference 2 (Appendix A), and Reference 4 (Section V).

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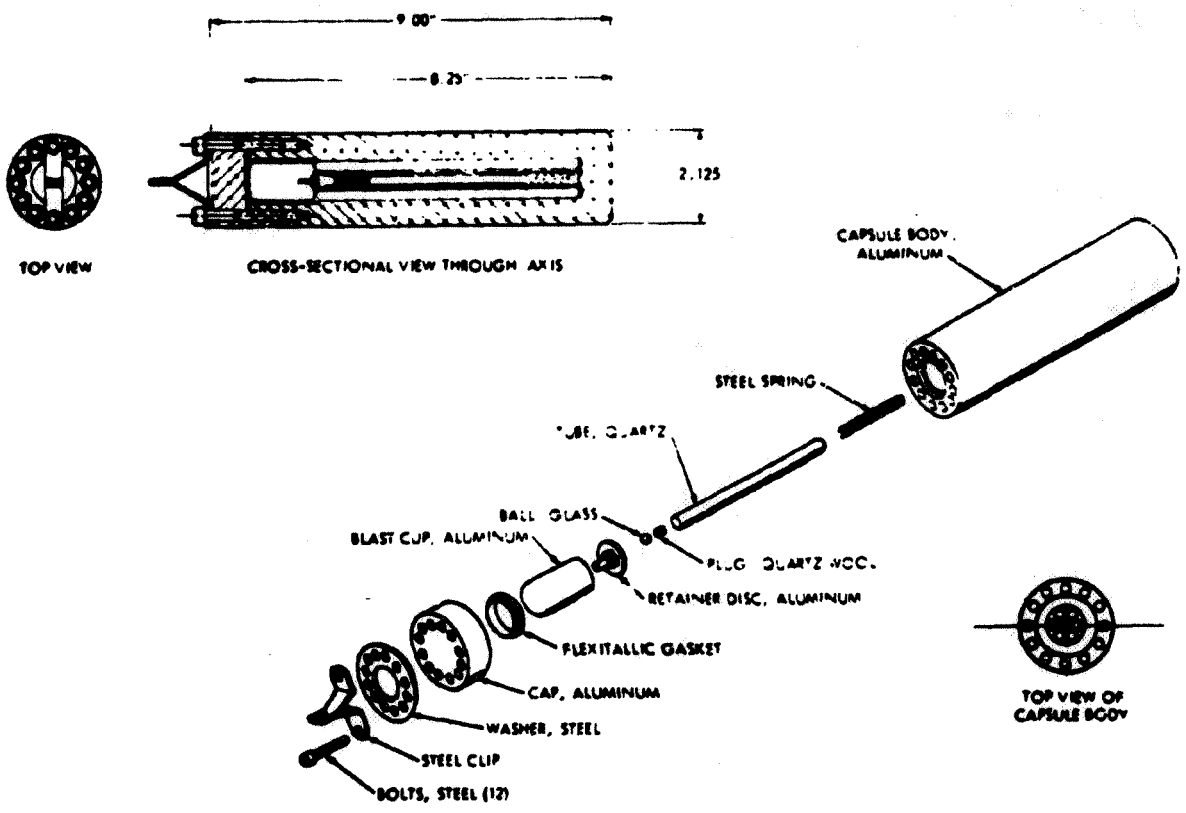

Figure 1

Internal Components of Non-Instrumented Capsule

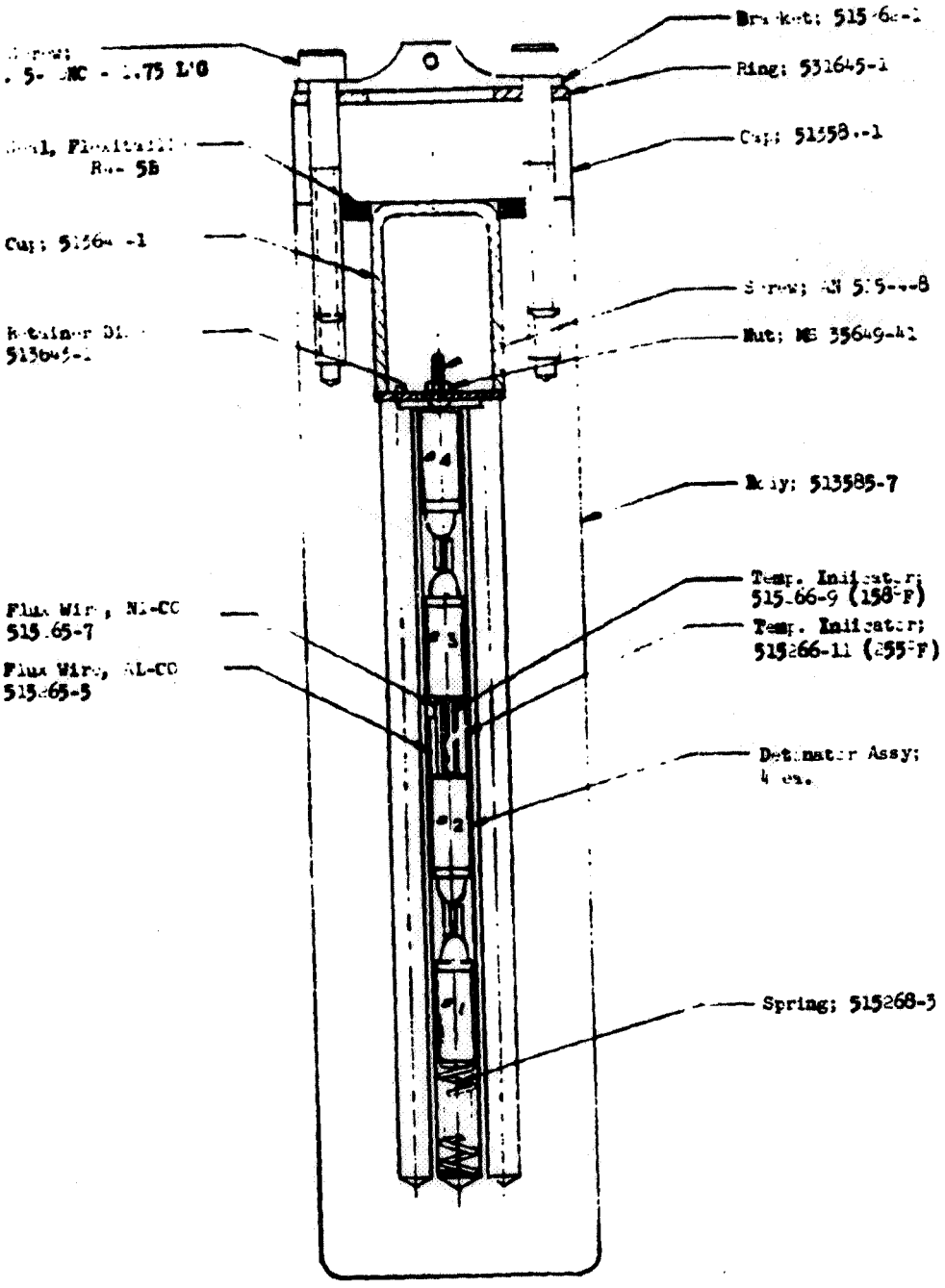

Figure 2

Detonator Loaded Capsule Assembly

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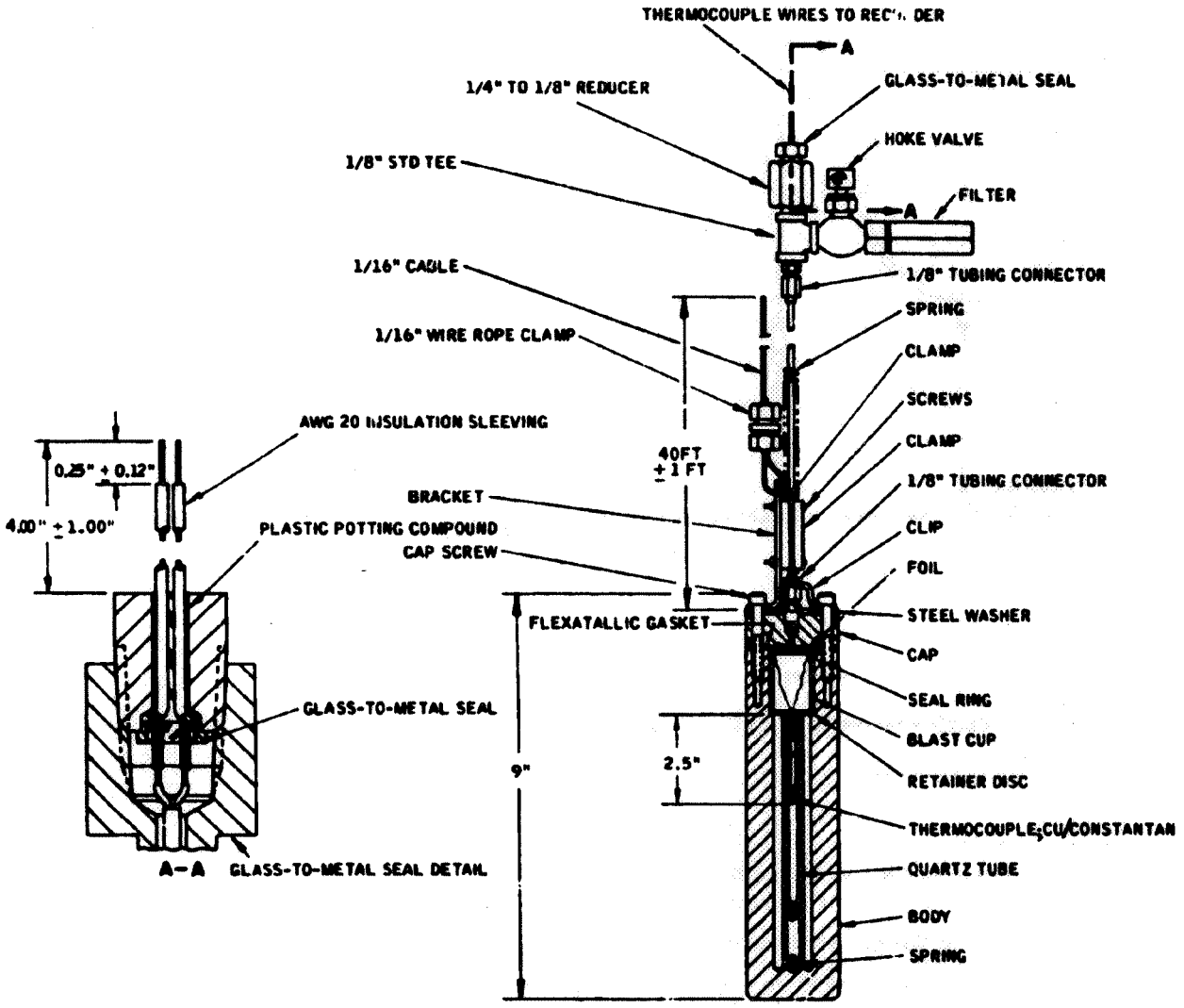
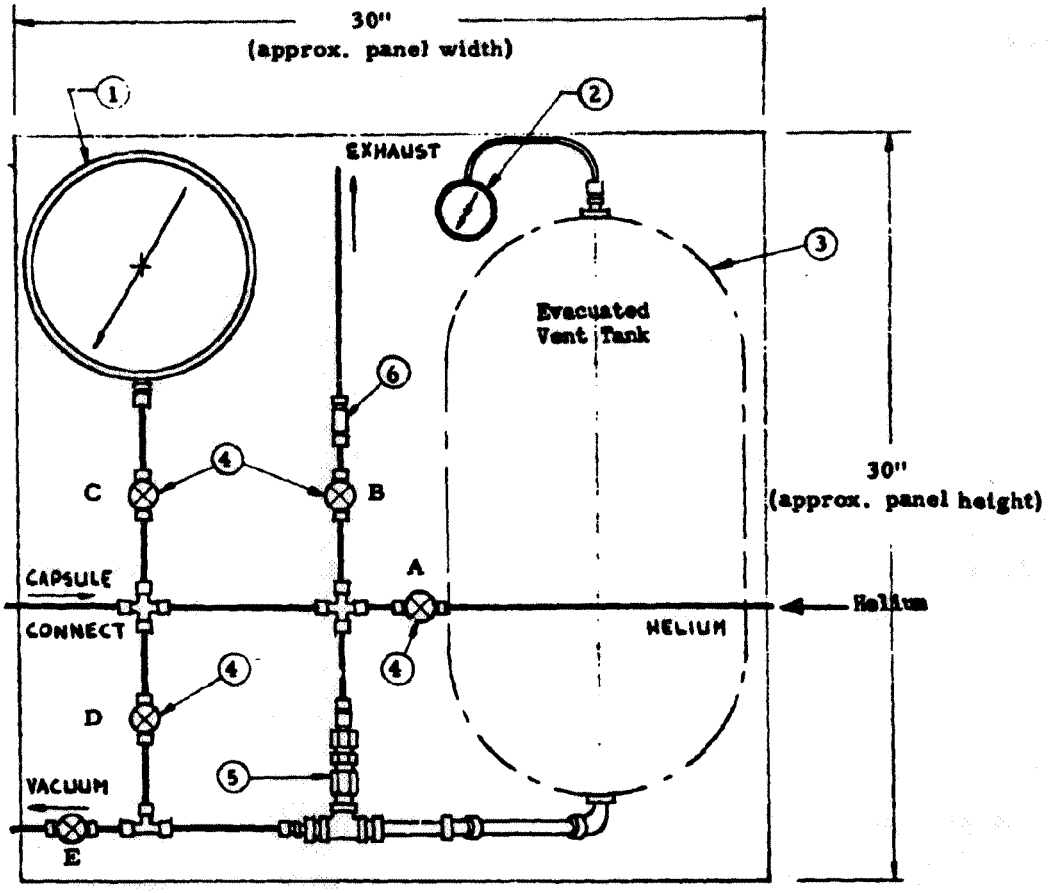


Figure 3

Instrumented Capsule Assembly



	Quantity	Description
1	1	Pressure Gauge, Heise 0-100 psi, 8-1/2" dial, .2 psi per division, 1/5 subdivided, with remote 5K potentiometer, 316 s.s. tube.
2	1	Vacuum Gauge, Marshalltown No. 22B, 2' dial size.
3	1	Vacuum Tank, 2000 cu. in., 12" x 24", s.s.
4	5	Needle Valve, Whitey No. OKS 2-316, 1/8" size, s.s. w/swagelok fittings.
5	1	Safety Head, screw type, Black, Sivalls & Bryson Assy No. SA-9; s.s. - 100 psia bursting pressure
6	1	Filter, Nupro "F" Series Inlet Filler, Cat. No. SS-2F-7, 5-10 microns, s.s.

Figure 4

Pressure Measurement Panel Diagram

The gas-pressure-measurement apparatus is used in conjunction with the instrumented irradiation capsule to permit a continuous measurement of pressure during irradiation. The apparatus itself consists primarily of a panel (Figure 4), the design of which includes a Swagelok capsule coupling, needle valves, safety heads, vacuum gage and tank, pressure gage, and exhaust filter. The Swagelok coupling connects to the filter of the instrumented capsule assembly shown in Figure 3.

Prior to irradiation, the instrumented capsule pressure-measurement assembly consisting of 40 ft of aluminum tubing (1/8 in. OD), junction seal bellows valve, capsule, and filter will be connected to the gas-pressure-measurement apparatus. The connection will then be pressure-checked for leakage with 50 psig of helium. Thereafter, the system will be vented to atmospheric pressure by opening and closing the vent valve (location B on Figure 4). The capsule valve will be opened and the capsule vented to the measurement system, and the capsule valve left open. The capsule will then be lowered into the Z-trail cable assembly and irradiated. During irradiation, joints in the piping system connected to the capsule will be monitored for leaks. After irradiation and retrieval, the entire system will be evacuated via Valve "D" into the vent tank, and the capsule valve closed. The tubing will then be disconnected from the panel and the aluminum tube coiled and loaded into the transfer cask along with the capsule.

Evacuation of the entire system before disconnection of the capsule is required to prevent escape of radioactive gases from the system. The vent tank is large enough (30 liters) to contain all the gases produced when 1.8 g of explosive burns within the capsule, and still remain at 1/30 atmosphere. Unless a sample burns, or a leak occurs, it will not be necessary to re-evacuate the vent tank. The activity of the vent tank will be monitored periodically, and it will be pumped out, if necessary, to keep the activity to an acceptable level.

In the event of a detonation within the capsule, the seal ring and blast cup will seal the capsule. Should they malfunction, the rupture disk to the vent

tank will open, relieving the pressure produced. As an additional safety factor, the tubing and capsule will contain the pressure released, without venting. The filter in the line will allow the tubing to be removed, and new capsules to be attached, without releasing contamination.

The temperature of the instrumented samples will be detected by a welded copper-constantan thermocouple imbedded in the powdered portion of the sample. The thermocouple wire is of a small diameter to permit the lead wire to fit inside the aluminum tubing and also to assure rapid response to temperature changes.

The measured thermocouple resistance is 80 ohms, and insulation resistance is over 2000 megohms. These values will be checked just before irradiation to verify that the thermocouples have not been damaged in transit. Copper-constantan thermocouple wire alloys were chosen to keep neutron activation to a minimum, produce a high voltage output, and allow use of a copper-wired millivolt recorder for both temperature and pressure.

The use of an oven set at 150 $\pm 0.2^{\circ}$F for the thermocouple cold junction compensation will permit increased sensitivity in the range of interest. This method of temperature measurement has been used successfully in Phase I-C irradiation tests on similar materials; thus no problems are anticipated due to the presence of radiation.

III. REACTOR EXPOSURE REQUIREMENTS

It is expected that by the time the Phase I-A capsules are irradiated, the GETR power level will have been increased from 30 to 45 megawatts. The samples will still be exposed in the peak flux position of the Z-trail cable facility; therefore shorter irradiation times will be required to produce the same exposures as in earlier phases. In addition, capsule samples will be heated to higher temperatures.

Neutron fluxes will be measured by nickel and aluminum-cobalt wires as described on page 12 of Reference 4. Gamma flux will be determined by calculation as developed for previous irradiation in Phase I-C. Exposure times will be finalized after predicted neutron and gamma fluxes are available from General Electric. Exposures desired are presented in the irradiation schedule (Table 1).

General Electric personnel will measure flux wire activity. They also will calculate (a) fast neutron, thermal neutron, and gamma dosages, (b) exposure rates, and (c) energy profiles.

The approximate irradiation schedule in Table 1 was prepared utilizing the test results from prior phases. However, the exposure needed to produce approximately 5% weight loss based on gas release volume will be used for the three instrumented capsules. Then, after they have been analyzed, the exposures for the non-instrumented capsules of the same materials will be set. In general these rates will be about half of the first capsule levels. This will provide information on the effect of different dosages on performance.

The following guidelines were used to set the irradiation schedule: (a) a maximum of three capsules will be irradiated in 1 day because of the limitation in transfer cask capacity, (b) not more than one instrumented capsule will be irradiated per day because of the long exposure times required, and (c) the second capsule of each type of material will not be irradiated until the results of the tests on the first one are obtained.

TABLE 1

IRRADIATION SCHEDULE

Capsule	Fast Neutron Exposure on Indicated Dates, $n/cm^2 \times 10^{16}$ (E70.18 Mev)						Remarks
	10/30 (Sun)	10/31 (Mon)	11/1 (Tues)	11/2 (Wed)	11/3 (Thur)	11/4 (Fri)	
AEN-1		20					Instrumented
AEN-2				10			
AEO-1			20				Instrumented
AEO-2					10		
AET-1				20			Instrumented
AET-2					10		
DAB-1	8						
DAB-2			4				
ADJ-1	8						
ADJ-2			4				
ADN-1	8						
ADN-2					4		

IV. OPERATIONAL PROCEDURES

To facilitate handling of the irradiation capsules and guarantee through data acquisition, the Program Manager at the General Electric Company Vallecitos Atomic Laboratory will issue explosive capsule data sheets, and instruct G.E. personnel on the data requirements, prior to performing any of the irradiations. These data sheets have been previously provided in Table 1 through 10 of Reference 3 and in Table 2 of Reference 4. They will again be issued as required.

A. IRRADIATION PROCEDURES FOR NON-INSTRUMENTED CAPSULES

Irradiation procedures for the non-instrumented capsules will be the same as previously described in Paragraph IV,B of Reference 4 (pages 17 and 18).

Written verification of exposure time will be obtained from Aerojet-General and the General Electric Program Manager prior to insertion of each capsule into the Z trail cable facility.

B. IRRADIATION PROCEDURES FOR INSTRUMENTED CAPSULES

Irradiation procedures for the instrumented capsules are basically the same as previously described in Reference 4. Since experience indicated that minor procedural changes would be of benefit, the revised procedures indicated below are proposed.

1. Exercise caution when handling the instrumented capsules. Do not twist aluminum tubing in relation to capsule or use it to support the weight of the capsule.

2. Connect capsule to pressure panel. Check to see that Valves A, B, D, and E are closed (Figure 4). Make sure valve from capsule, and Valve C are open.

3. Check resistance of thermocouple, and insulation resistance. Attach thermocouple wires to the terminal strip on the panel.

4. Check to see that steel cable and tubing fittings are properly connected and tight. Turn on recorder.

5. Slowly open Valve A and pressurize panel and connection as far as capsule valve (Hoke Valve, Figure 3) with helium to 50 psi. Shut off helium valve and check to see that pressure does not decrease over a 5-min period. Check connections with a soap solution and tighten, if necessary, to make leak-tight joints. Check recorder against indicator on pressure gage.

6. Release pressure by opening Valve B in increments of 10 psi, and mark location of recorder needle when pressure gage shows 50, 40, 30, 20, and 10 psi, respectively. Bleed off pressure to 0 psi, and close Valve B.

7. Open the capsule valve and then slowly open Valve A to bleed helium into the capsule, or Valve B to remove it, until 0 psi is indicated.

8. Carefully lower capsule into location of peak flux in Z-trail cable facility.

9. Record initial time, temperature, and pressure, plus the same data as for non-instrumented capsules.

10. Check pressure gage vs recorder readings, and mark chart with gage readings and time periodically.

11. Watch temperature and pressure recordings; stop irradiation if pressure exceeds 40 psi, or temperature exceeds 200°C.

12. Discontinue radiation after 5 hours (if not stopped sooner) by withdrawing capsule from irradiation zone and recording data as before.

13. Open Valve D to vent tank to reduce pressure to below atmospheric. Close valves and disconnect tubing and thermocouples from panel.

14. Transfer capsule to reactor canal.

15. After samples have cooled in canal, withdraw capsule into transfer cask coiling up the aluminum tube in the process.

C. POST-IRRADIATION PROCEDURES

Irradiated capsules will be allowed to cool in the reactor pool until 6 A.M., then transferred to the RML by 7:30 A.M.

The procedure for transferring of irradiated capsules from the test reactor (GETR) to the Radiological Materials Laboratory (RML), as well as RML (hot cell) o cell) operations such as gas release measurement and capsule disassembly, will be the same as previously described in Paragraph D of Reference 4 (pages 19-28).

D. EXPLOSIVE TESTING PROCEDURES

Pressure will be measured in the three non-instrumented explosive capsules (AEN-2, AEO-2, and AET-2). The non-instrumented capsules will then be opened using the lathe. The top of the capsules will be cut off near the retainer disk as was done before. Instrumented capsules will be opened by removal of the twelve cap screws and cap. Thermocouples will be removed from the three instrumented capsules (AEN-1, AEO-1, and AET-1), and the quartz vials from the six capsules containing explosives (AEN-1, AEN-2, AEO-1, AEO-2, AET-1, and AET-2) will be transferred to the RML basement laboratory for analysis as was done in Phase I-C. Tests will include (1) weight loss, (2) DTA, (3) TGA, (4) explosion temperature, (5) vacuum stability, and (6) melting point (on AET-1 and AET-2 only)

Excess material samples will be saved and sent to the Naval Ordnance Laboratory for thin-layer chromatography. Control tests will be made on these same explosives, and also on the explosives used in the detonators. Procedures for these tests are the same as previously reported (References 2 and 4).

Flux wires will be removed and sent to the General Electric Chemistry Laboratory for counting. Temperature monitors will be removed and the temperature range of the samples reported. No propellant samples will be tested in this series. Samples from capsules AET-1 and AET-2 will have melted during irradiation, and the quartz vials will have to be crushed to remove them as was done with the melted samples in Phase I.

E. DETONATOR TESTING PROCEDURE

A total of four detonators, two temperature monitors, and two flux wires will be loaded into each of six capsules (ADN-1, ADN-2, ADJ-1, ADJ-2, DAB-1, and DAB-2). Although the internal explosives will vary, all units will use the same outer case and assembly as shown in Figure 5.

TOTAL ASSY WEIGHT: 2.67 - 2.76 GM

TOTAL EXPLOSIVE WEIGHT: 0.40 - 0.45 GM

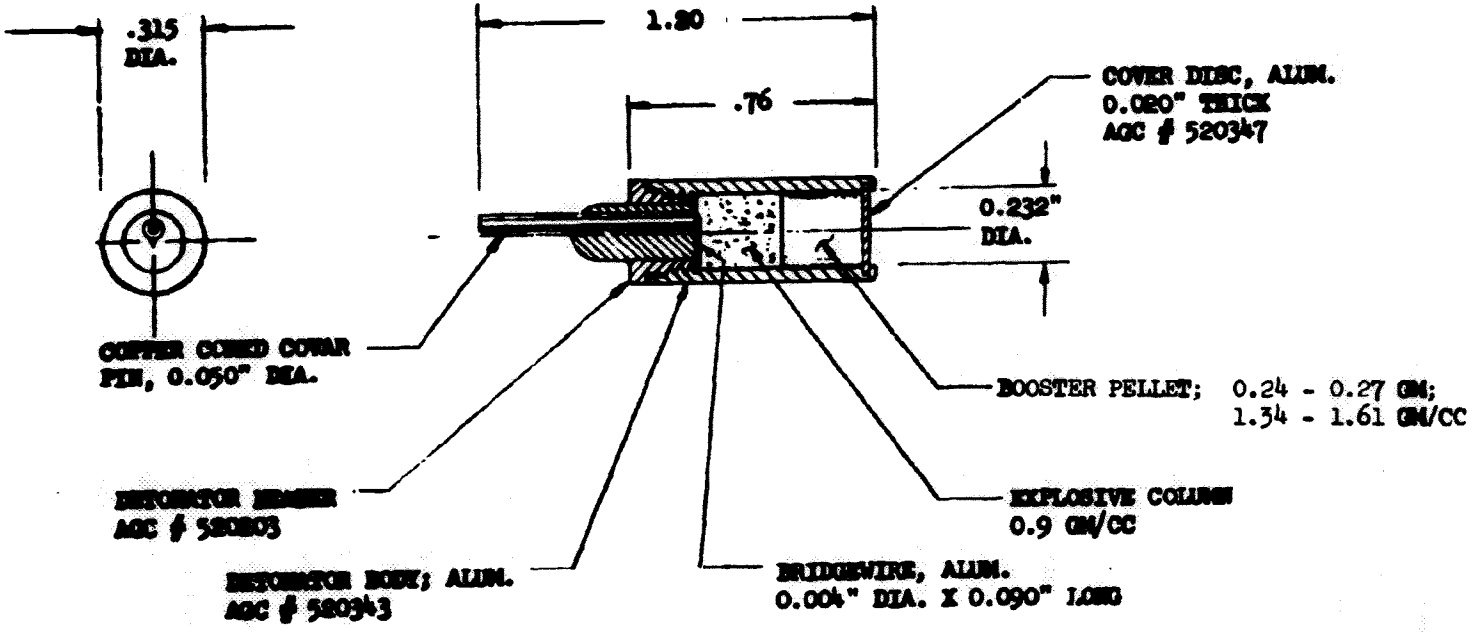


Figure 5

Prototype Radiation Stable Detonator Assembly

Two capsules of each type of detonator will be irradiated. The first capsule will be irradiated for a length of time near its threshold as determined from the prior phases. After testing, the dosage of the second capsule of the same detonator will be established in an attempt to bracket the exposure dosage at which significant performance changes are encountered.

After irradiation, the capsules will be transported to the RML for pressure measurement. The capsules will be opened in the standard manner either by removal of the twelve cap screws or by cutting off the top at the inner end of the blast cup. Enough clearance has been allowed (0.00[illegible] to 0.013 in.) to allow the detonators to slide out of the center hole of the capsule. However, if necessary, the bottom of the capsule could be cut off about 1 in. above the bottom to allow them to be pushed out. The X-ray of the capsule will be measured to determine the exact location of the cut.

After removal from the capsule, the temperature monitors should be transferred to the basement laboratory for examination, and the flux wires sent to the Chemistry Laboratory for counting. The induced radioactivity of the detonators will be high enough so that it will be desirable to test fire them in the RML hot cell. They will be loaded into the firing chamber shown in Figure [illegible], and fired. A firing rack, a Moran 101 raster oscilloscope, and a Tektronix 555 dual-beam oscilloscope will be located outside the cell as shown in Figure 7. Measurements will be made of the bridge wire resistance before and after insertion into the firing box. If resistance in the firing unit is significantly different, contacts in the firing box will have to be cleaned or replaced. At the time of firing, the current, the voltage, and the firing time will be recorded. After firing, plate dents will be measured.

The loading and firing procedure for detonators will be as follows:

1. Weigh individual detonators on an analytical balance.
2. Measure bridge wire resistance by inserting in bridge-wire test fixture connected to Alinco ohmmeter.
3. Open firing box and clean inside. Dump transformer oil out of center well. Save witness block from prior test, and discard rest of residue. Check resistance of firing line; if below 10,000 ohms, clean insulator at bottom of firing well.

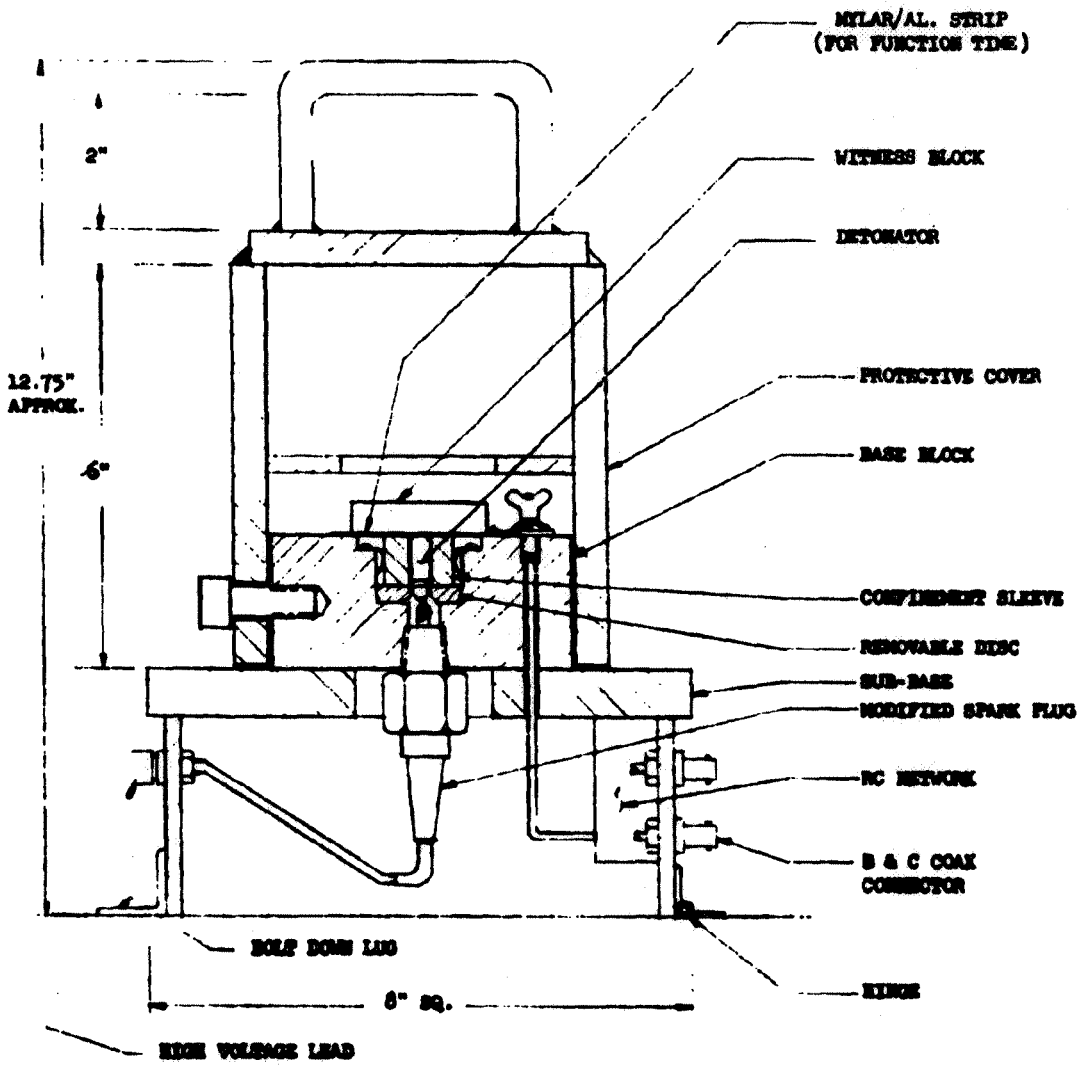


Figure 6

Detonator Firing Fixture

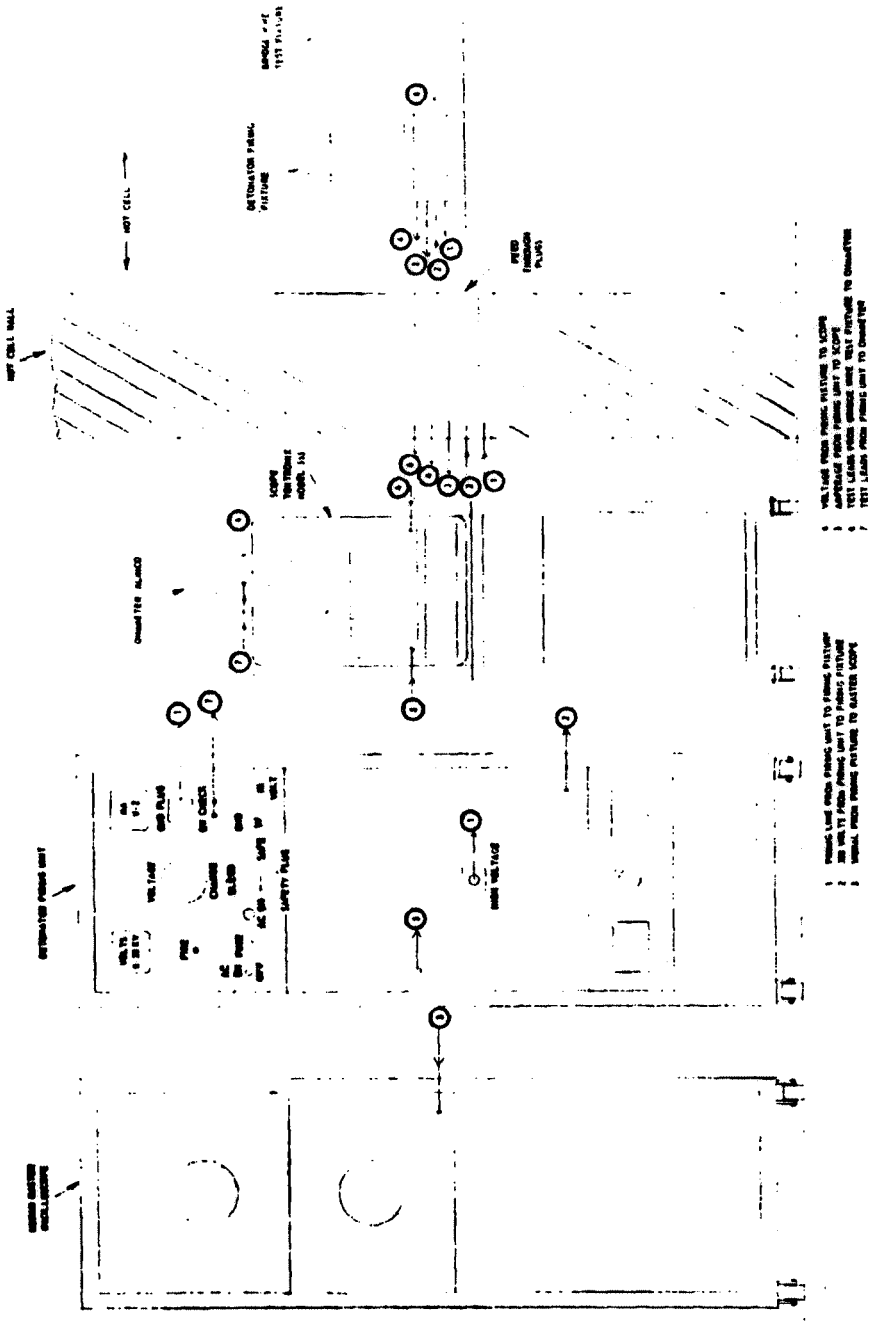


Figure 7

Detonator Firing Apparatus

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4. Fill lower firing well about half full of clean transformer oil (about 1/2 cc).

5. Put support disk and confining sleeve in fixture.

6. Check to see that firing line is shorted at panel.

7. Line up index marks on detonator & firing unit and insert detonator.

8. Stretch Mylar/Aluminum strip across end of detonator, and connect to terminal. Check resistance across film.

9. Put witness block over end of detonator.

10. Put cover on firing chamber, and lock in place.

11. Check bridge-wire resistance with Alinco ohmmeter. If resistance differs by more than 0.02 ohm from that in Reference 2, disassemble, determine cause of trouble, and correct. If resistance is approximately equal to the pre-assembly value, the unit is ready for firing.

12. Connect detonator leads to high-voltage terminal.

13. Check operation of oscilloscopes, set in firing positions, and check film in cameras.

14. Turn on high voltage, and charge capacitor to desired voltage.

15. Open camera shutters, push firing button, and close shutters.

16. Remove pictures from cameras and save for measurement of firing time, voltage, and current.

V. HAZARDS AND SAFETY REVIEW

Radiological safety monitoring shall be performed in accordance with standard General Electric procedures. General Electric shall have the responsibility for providing film badges, dosimeters, radiation monitoring gages, etc., to all non-General Electric personnel at Vallecitos in connection with this program. In addition, General Electric will provide complete radioactive safety monitoring of all testing procedures (including ventilation) and assigned personnel. All non-General Electric personnel shall follow General Electric instructions regarding safety.

General loading instructions for irradiation capsule assembly are to be found in Appendix A.

The ability of the capsule to contain the detonation of an explosive depends upon proper assembly. Therefore, all critical assembly steps will be witnessed by a quality control inspector. A typical certification of acceptance is shown in Appendix B. As a double check, X-rays showing the internal assembly will be taken of all loaded capsules; these X-rays will be examined by Aerojet personnel and then forwarded to General Electric for review.

Hazards associated with the handling and testing of the six explosive loaded capsules are the same as in Phase I-C (Reference 4), and will not be repeated here. The six capsules of detonators are loaded with the same explosives already tested in Phase I-C. They require a pulse of very high voltage and current to explode the bridge wire before they will detonate; therefore no unusual electrostatic sensitivity problems will be encountered. The radioactivity induced in the cobalt and copper in the glass-to-metal seal will make it necessary to fire them remotely in the hot cell. A steel firing chamber will be used to confine the blast and fragments during firing. However, the gas generated when the explosion occurs will be released into the cell. This is a very small quantity (about 300 cu cm of gas at STP from the 0.4 g of explosive in each detonator) and can be easily handled by the hot cell exhaust system.

Although it is very unlikely that a detonator would detonate while testing bridge-wire resistance, the cover of the firing chamber will be set over it while

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this is being accomplished. The firing unit is provided with a separate grounded plug. The detonator firing line will be plugged into this and grounded (green light on) at all times when the firing chamber is open so as to prevent premature firing of a detonator. In addition, a safety plug on the high-voltage power supply will be removed except when the firing line is connected to the firing plug. This will protect personnel from being shocked by the open plug, even though no voltage appears on this plug until the firing button is pushed.

The back of the firing unit should be kept closed except for repairs. If it is necessary to open the back of the firing unit, all high-voltage terminals should be grounded with a grounding strap before repairs are attempted.

VI. REFERENCES

1. Addendum to Report No. 2510, Final Test Specifications for Phase I of the Countermeasures Radiation Effects Program, Contract SNP-1, December 1963 (Unclassified).

2. Addendum No. 2 to Report No. 2510, Final Test Specifications for I-B of the Countermeasures Radiation Effects Program (U), Contract SNP-1, September 1964 (Confidential).

3. Addendum No. 3 to Report No. 2510, Final Test Specifications for Transient Nuclear Test (KIWI-TNT) of the Countermeasures Radiation Effects Program, Contract SNP-1, December 1964 (Unclassified).

4. REON Report RN-S-0235, Addendum No. 4 to Report No. 2510, Final Test Specifications for Phase I-C of the Countermeasures Radiation Effects Program, Vol. I (Text and Unclassified Appendixes), Contract SNP-1, July 1965.

APPENDIX A

LOADING INSTRUCTIONS FOR IRRADIATION CAPSULE ASSEMBLY

I. GENERAL INSTRUCTIONS

A. Record temperature and humidity in glove box at time the explosives, or detonators, are loaded into their respective tube assemblies.

B. Record barometric pressure and temperature (as obtained downstairs) at 8:00 am and 12:30 pm every loading day.

C. Scales must be "checked for zero" each time a weighing is to take place. Make sure no heavy objects are placed (or removed) from the table or bench on which the scale is sitting once the scale has been "zeroed."

D. Allow scales to come to complete rest before taking reading.

E. Ultrasonic-clean all temperature and flux indicators in acetone; do not touch with bare hands after cleaning. (Note: Clean one type at a time to avoid mixups.)

F. Ultrasonic-clean the following parts: quartz tube assemblies, retainer disk, and blast cups.

G. Keep powdered explosives and propellants clean and free from contamination. Replace container lids immediately after removal of material.

H. All powdered explosives shall be dried to "constant weight" or handled in accordance with standard drying procedures before being loaded into the sample tubes.

I. Use a rubber stopper to cap off tube assemblies when they are removed from the glove box for weighing.

J. Make sure glove box is properly flushed with helium before loading or assembly starts.

K. It is imperative that the proper flux and temperature indicators be used in each tube assembly. Maintain identities by opening and removing indicators from one container at a time. Indicators can be identified visually on the basis of the measurements given below.

Drawing Number	Description	Length of Vial in.	Length of Wire in.
518255-1	Flux Indicator (Al-Co)	0.75	0.44
518255-3	Flux Indicator (Ni-Co)	0.75	0.44
518256-1	Temperature Indicator (198°F)	1.12[1]	0.5
518256-3	Temperature Indicator (255°F)	1.12[1]	0.5

[1]Partially filled with water.

L. Although nesting position of flux and temperature indicators in the tube assemblies is optional, every effort should be made to maintain the sequence and approximate position shown on the tube assembly drawing.

II. ASSEMBLY, LOADING, AND TESTING INSTRUCTIONS FOR INSTRUMENTED CAPSULE ASSEMBLY (P/N 518247-1)

A. ASSEMBLY OF T/C WIRE AND PRESSURE LEAD

1. Cut off 40 ft of 1/8 in. OD aluminum tubing, slip tube support (P/N 518253) over one end, and one tube connector nut and ferrule over each end. Flare tube ends using 37° Imperial flare tool.

*2. Inspect flared ends - no cracks or thinned-out flanges allowed

3. Push music wire (0.024 in. dia) through tube, make hook on emerging end, fasten free end of T/C wires, and pull T/C wire through tubing. Cut T/C wires allowing approximately 1-1/2 ft extending out on each end of tubing.

*Procedure completion to be certified by Quality Control.

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[illegible]. Assemble valve (Hoke [illegible] AK), filter (Hoke [illegible] F4B), [illegible] in. brass tee, reducing adapter (Cajon [illegible]-RA-[illegible]), and male part of tube connector (Imperial [illegible]-PS) per I.P. Use Teflon tape on joints.

[illegible]. Check to see that valve is closed and joints tight.

[illegible]. Push T/C wire through tube connector, straight run of tee, and reducing adapter.

[illegible]. Remove outer insulation as required, and then remove individual T/C wire insulation for approximately [illegible] in.

[illegible]. Thread bare T/C wires through lead through tubes in seal assembly (P/N [illegible]), and solder T/C wires in place in accordance with I.P.

[illegible]. Thread insulating tubing ("spaghetti") over bare end of T/C wires and fill seal assembly with potting compound (MH Corp. No. TC-[illegible]).

[illegible]. Hold seal assembly stationary, and turn adapter-tee assembly onto seal assembly.

11. Assemble male part of steel tube connector (Imperial [illegible]-PS) to cup (P/N [illegible]).

12. Thread tail of T/C wires through ring (P/N [illegible]), cup (P/N [illegible]) w/connector, seal (RA-[illegible]), protection disk (P/N [illegible]), and seal ring (P/N [illegible]).

13. Peel off outer insulation on T/C wire up to base of cup. Coat ends of individual T/C wires with Eastman 910 cement (approximately 1/2 in.).

14. Thread T/C wires through holes in cup (P/N 513155) and push individual T/C wires into groove in cup. Place small amount of water glass on bottom of protection disk and press down on top of cup. Allow to dry.

15. Thread T/C wires through center hole in retainer disk (P/N 513145).

16. Secure assembly with masking tape and send assembly to Engineering Laboratory for welding of the T/C junction.

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*Procedure completion to be certified by Quality Control.

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B. LOADING OF TUBE ASSEMBLY AND ASSEMBLY OF CAPSULE

1. Verify that tubes (P/N 915264-3) will fit freely in cavity of body (P/N 915285-7) in which they will be used.

*2. Mark tube on side with identification symbol and serial number using felt pen.

*3. Mark body (915285-7) with identification symbol and serial number (minimum of 1-in.-high letters on side of body and minimum of 1/4-in.-high letters on bottom using vibratool and felt pen).

*4. Weigh out approximately 1.8 g of test material (explosive or propellant) on analytical balance. Record total weight explosive and pan to ±0.0001 g.

*5. Weigh and record the weight of all paraphernalia (such as funnel, glass disk, Kimwipes, etc.), including the pan containing the test sample to be used in loading the tube assembly.

6. Load tube assembly approximately half full in accordance with B/P and insert T/C junction into this depth with the junction approximately in the center of the tube.

*7. Continue to load tube assembly with test material and indicators, and plug off with quartz wool in accordance with B/P.

*8. Insert tube into capsule assembly and follow with the remaining capsule hardware strung on the T/C wire, making sure each component is properly assembled.

9. Insert two cap-screws to secure cap.

*10. Weigh all items used in loading the tube assembly. The difference between this weight and the original weight with the test materials determines the exact amount of test material in the tube. (Note: Net amount of test material in tube shall be 1.8 ±0.05 g.)

*Procedure completion to be certified by Quality Control.

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11. Place capsule body in vise, insert remaining bolts, clamping bracket (P/N 518252), and locking bracket (P/N 518250).

*12. Tighten 12 bolts to 100 in.-lb; tighten across.

*13. Tighten 12 bolts to 200 in.-lb; tighten around.

14. Attach clamps (P/N 518251 -1 and -2) with screws and nuts in accordance with B/P.

15. Check T/C wires for continuity and ascertain that they are not shorted to capsule assembly.

C. LEAK-TESTING OF CAPSULE ASSEMBLY

1. Attach capsule assembly to pressure-measuring apparatus, open valve, and submerge capsule assembly in water.

*2. Slowly bleed helium into capsule to a maximum pressure of 100 psig. Check for leaks, and correct if necessary.

3. Slowly release pressure down to atmospheric pressure; close and seal valve.

*D. CALIBRATE CAPSULE INTERNAL VOLUME AGAINST KNOWN VOLUME, AND RECORD DATA.

*E. X-RAY CAPSULE BODY TO CONFIRM THAT ALL PARTS ARE PROPERLY ASSEMBLED.

*F. ATTACH 40 FT OF CABLE AND CLAMP IN ACCORDANCE WITH B/P; VERIFY THAT ASSEMBLY IS COMPLETE.

G. ATTACH INSPECTION TAG.

H. PACKAGE CAPSULE ASSEMBLY IN ACCORDANCE WITH APPLICABLE INTERSTATE COMMERCE COMMISSION (ICC) REGULATIONS.

III. LOADING, ASSEMBLY, AND TESTING INSTRUCTIONS FOR NON-INSTRUMENTED CAPSULE ASSEMBLY CONTAINING POWDERED EXPLOSIVES (P/N 513646-21)

A. LOADING OF TUBE ASSEMBLY (P/N 515267-3)

1. Assemble component parts and material required for tube assembly (515267-3).

2. Verify that tubes (515264-3) will fit freely in cavity of body (513585-7) in which they will be used.

*Procedure completion to be certified Quality Control.

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3. Mark tube ([illegible]-3) on side with identification symbol and serial number, using felt pen.

4. Prepare test material (powdered explosive) and component tube assembly hardware as follows:

a.* Weigh together on analytical balance to the nearest 0.0001 g the component parts of tube assembly ([illegible]-3), excluding the explosive.

b. Weigh out approximately 1.[illegible] g (or sufficient amount to obtain a total of 1.8 ±0.05 g net weight of explosives in test tube after loading) of pre-dried explosives on analytical balance.

c. Place component parts and explosive inside glove box, and flush thoroughly with helium.

d. Load explosive, flux and temperature indicators into tube in accordance with Drawing 515207-3 and general loading instructions. Remove capped tube from glove box.

e.* Weigh tube assembly (515207-3) on analytical balance to the nearest 0.0001 g. Place in glove box.

B. ASSEMBLY AND TESTING OF CAPSULE ASSEMBLY (P/N 513646-21)

1. Assemble component parts required for the capsule assembly in accordance with Drawing 513646.

2. Mark body (513585-7) with identification symbol and serial number (minimum of 1-in.-high letters on side of body and minimum of 1/4-in.-high letters on bottom using vibratool and felt pen).

3. Assemble irradiation capsule assembly in accordance with Drawing 513646.

a. Place component parts inside loading chamber.

b. Flush loading chamber with helium.

c.* Assemble parts in the following sequence:

*Procedure completion to be certified by Quality Control.

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(1) Insert compression spring.

(2) Place tube assembly in position.

(3) Insert retainer disk (with screw and nut).

(4) Insert plastic cup.

(5) Put gasket in place.

(6) Place cap in position; position steel washer.

(7) Insert two bolts.

c. Seal irradiation capsule

(1) Tighten two bolts finger tight.

(2) Remove capsule from chamber and place in vise.

(3) Insert remaining ten bolts and bracket.

(4)* Tighten twelve bolts to 180-in.-lb; tighten across.

(5)* Tighten twelve bolts to 200-in.-lb; tighten around.

e. Weigh assembled capsule on scale to an accuracy of 0.1 g.

4. Perform Leak Check

a. Place capsule in vessel filled with water.

b. Draw vacuum over surface of liquid for 5-10 min.

c. Release vacuum and leave capsule in water for 30 min.

d.* Remove capsule from water, dry, and weigh capsule. If weight gain exceeds 9 g, reload capsule.

5. X-ray capsule to confirm that all parts are properly assembled.

6. Affix inspection tag.

7. Package irradiation capsule in accordance with applicable Interstate Commerce Commission regulations.

*Procedure completion to be certified by quality control.

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IV. LOADING, ASSEMBLY, AND TESTING INSTRUCTIONS FOR NON-INSTRUMENTED CAPSULE ASSEMBLY CONTAINING DETONATORS (P/N [illegible]), PHASE I-A TESTING

A. ASSEMBLY AND TESTING OF CAPSULE ASSEMBLY

1. Assemble component parts required for the capsule assembly in accordance with Drawing [illegible].

2. Mark body ([illegible]) with identification symbol and serial number (minimum of 1-in.-high letters on side of body and minimum of 1-in.-high letters on bottom using nitric acid and felt pen).

3. Mark detonator assemblies ([illegible]) with identification symbol and serial numbers through [illegible], and index side closest to pin using felt pen.

4.* Weigh each detonator assembly on analytical balance to the nearest 0.0001 g, and record weights.

5. Assemble irradiation capsule assembly in accordance with Drawing 520148.

a. Place detonators and component parts inside loading chamber.

b. Flush loading chamber with helium.

c.* Assemble parts in the following sequence:

(1) Insert compression spring.

(2) Place detonators No. 1 and 2 in position.

(3) Wrap flux wires and temperature indicators in aluminum foil as required. Form into cylindrical package that will fit freely in the cavity of the capsule body. Insert into cavity.

(4) Insert the remaining detonators (No. 3 and 4).

(5) Insert retainer disk (with screw and nut).

*Procedure completion to be certified by Quality Control.

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(6) Insert plastic cup.

(7) Put gasket in place.

(8) Place cup in position; position steel washer.

(9) Insert two bolts.

d. Seal irradiation capsule:

(1) Tighten two bolts finger-tight.

(2) Remove capsule from chamber and place in vise.

(3) Insert remaining ten bolts and bracket.

(4)* Tighten twelve bolts to 100-in.-lb; tighten across.

(5)* Tighten twelve bolts to 200-in.-lb; tighten around.

e. Weigh assembled capsule on scale to an accuracy of 0.1 gram.

5. Perform leak-check

a. Place capsule in vessel filled with water.

b. Draw vacuum over surface of liquid for 5 to 10 min.

c. Release vacuum and leave capsule in water for 30 min.

d.* Remove capsule from water, dry, and weigh capsule. If weight gain exceeds 9 g, reload capsule.

7. X-ray capsule to confirm that all parts are properly assembled.

8. Affix inspection tag.

9. Package irradiation capsule in accordance with applicable Instate Commerce Commission regulations.

*Procedure completion to be certified by Quality Control.

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APPENDIX B

INSPECTION INSTRUCTIONS FOR CAPSULES

Typical inspection instructions for irradiation capsules are given on the four pages to follow.

Aerojet-General

P NO 513646		PAGE 1	PART # 513646-21
CHG LTR D ECO	INSPECTION INSTRUCTION	OF 4	PLANNING ORDER NO
PROJECT MODEL RECON			PART NAME IRRADIATION CAPSULE ASSY
LOT SIZE / UNIT SERIAL / LOT NO		ISSUE DATE 5/24/65	REV DATE / REV NO / REVISED BY

ITEM NO	REV CAT	OPER NO / VEND CODE	CHARACTERISTIC			TYPE OF CODE OR INSPECTION EQUIPMENT	SPEC NO	SAMPLE VALUE	INSP FREQ & %	INSP STATUS
			Record Shop Order No. _____							
1			Verify evidence of previous AOC inspection and acceptance of component parts:							
			513584-1	Cap	(1)	S/O				
			513585-7	Body	(1)	S/O				
			513642-1	Cup	(1)	S/O				
			513643-1	Retainer Disk	(1)	S/O				
			513645-1	Ring	(1)	S/O				
			515262-1	Bracket	(1)	S/O				
			515267-3	Tube Assy	(1)	S/O				
			515268-3	Spring	(1)	P/O				
			AN515-4-8	Screw	(1)	Certs				
			MS35649-41	Nut	(1)	Certs				
			.25-20UNC2A	SCK HD Cap Srew Steel	(12)	*Certs				
			Com'l Prod. R4-25B	Seal	(1)	**Certs				
			Com'l Prod. 7.5 MM Dia.	Glass Ball Perforated	(1)	**Certs				
2			Record calibration dates of all gages and tools to be used on attached recording sheet.			Visual			100%	
3		G/W 5	Assembled per instructions given on Work Release and on Assembly Loading and Testing Instructions.			Witness/ Visual			100%	

PREPARED BY [signature]

APPROVED BY [signature]

REMARKS *Certifications must conform to G/W #'s 1,3 and 4. **Certifications must conform To G.W #'s 1 and 4

** RECORD VALUES CODED THUS *

PART NO / PLANNING ORD NO

Aerojet-General

P/N 513646	INSPECTION INSTRUCTION	PAGE 2 OF 4	P/N 513646-21
PROJECT MODEL NERVA			PART NAME IRRADIATION CAPSULE ASSY
		ISSUE DATE 5/24/65	

			CHARACTERISTIC						
4			FOLLOWING APPLIES TO 515267-3 ASSY ONLY Verify for previous ACCInspection acceptance by means of IPS, P.O. or Certs for detail parts used in this assembly. NOTE: Certs must conform to G/H #3			Visual				
			515264-3	Tube	(1)	IPS				
			515265-1	Flux Indicator	(1)	IPS				
			515265-3	Flux Indicator	(1)	IPS				
			515266-1	Temperature Indicator (158°)	(1)	IPS				
			515266-3	Temperature Indicator (255°)	(1)	IPS				
			Material	Explosive 2	(AR)	P.O.				
			Com'l Prod.	Quartz Wool	(AR)	Certs				
5		G/H 6	Verify free movement, prior to loading explosives, of tube in cavity of the body 513585-7. Identify tube with S/N using felt pen. Identify body with S/N using felt pen and vibro tool.			Manual/ Visual			100%	
6			Witness weighing of detail parts, excluding explosives, and record on attached recording sheet.			Analytical Scale			100%	
7			Verify that loading of explosives complies with loading instructions and Dwg. 515267-3			Witness			100%	
8			Witness weighing of 515267-3 assembly after loading of explosives and record on attached recording sheet.			Analytical Scale			100%	
9			.38 Min. Dim.			Scale/ Visual			100%	

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APPROVED BY M. L. Hinkle

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Aerojet-General

P/N 513646- CHG LTR D

PROJECT MODEL RECN

INSPECTION INSTRUCTION

SHT 3 OF 4

513646-21

PART NAME IRRADIATION CAPSULE ASSY.

5/24/65

			CHARACTERISTIC				
10			Record actual amount and type of explosive used on attached recording sheet.	Subtract findings of Char. 6 from 8			100%
11			Container identified per ASD 5215M	Visual			100%
			FOLLOWING APPLIES TO 513646-21 FINAL ASSY				
12			Body 513585-7 identified with S/N on side and bottom with felt pen and vibro teal.	Visual			100%
13			Capsule assembled per S/P, Assembly, Loading and Testing Instructions.	Witness/ Visual			100%
14		G/N 6	Spring and seal to conform to G/N #6	Depth Gage			100%
15		G/N 7	Cap screws torqued to 170-200 inch lbs.	Torque Wrench			100%
16		G/N 8	2.156 max. envelope Dia. for noted length.	Micro.			100%
17			Witness and record weight of assembled capsules, prior to leak test, on attached recording sheet.	Manual/ Visual			100%
18			Witness and record weight of assembled capsule, after leak test, on attached recording sheet.	Manual/ Visual			100%
19			Verify that capsules have not gained more than 8 grams. NOTE: Capsules that gain more than 8 grams are to be reloaded.	Subtract findings of Char 17 from 18			100%
20			Component parts have been assembled properly.. (To be determined after assemblies have been X-Rayed.)	Review X-Rays			100%
21			Tagged with P/N per ASD 5215M	Visual			
22			Record lot No. in appropriate block				

INSPECTION COPY

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AEROJET-GENERAL CORPORATION

DOWNEY, CALIFORNIA

LOT NO.	TEST DATA RECORDING SHEET	MODEL/ PROJECT NERVA
DATE STARTED:	PART NUMBER: 513646-21	TEST ENGINEER:
DATE COMPLETED:	PART NAME: IRRADIATION CAPSULE ASSEMBLY	TEST PERFORMED BY:
	TEST PERFORMED: AS NOTED BELOW	WITNESS AND/OR APPROVED

EXPLOSIVE WELDING

Ref.: Char. 6, 8, and 10

S/N	SHEET	LOADED	DIFF.	MIN. REQ'D

LEAK TEST

Ref.: Char. 17, 18 and 19

S/N	BEFORE	AFTER	DIFF.

CALIBRATION DATES AND NAME OF GAGES USED (Char. 8)

GAGE NAME	USE DATE	GAGE NAME	USE DATE	GAGE NAME	USE DATE

PAGE 6 OF 6

Prepared By: [signature] Approved By: [signature]